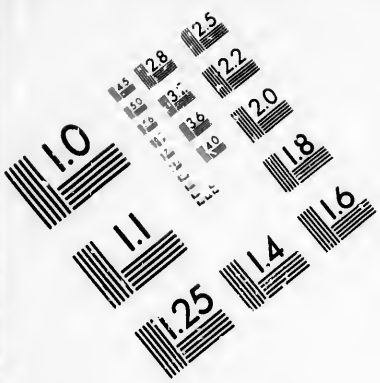

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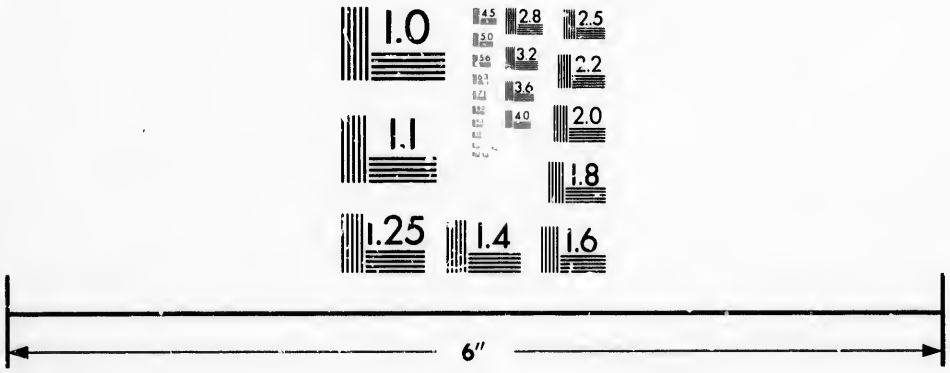

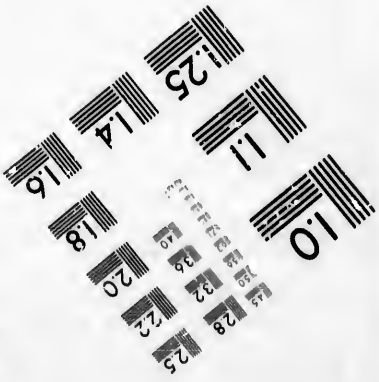

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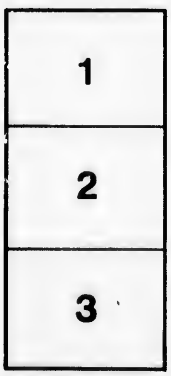

THE WHOLE HISTORY AND MYSTERY

OF

BEET-ROOT

AND

BEET-ROOT SUGAR:

CONDENSED AND SIMPLIFIED AND ADAPTED TO THE USE OF THE FARMER, AND THE SMALL MANUFACTURER, ANY OF WHOM MAY, BY FOLLOWING THE WITHIN INSTRUCTIONS, MANUFACTURE A MERCHANTABLE ARTICLE OF A ROUGH SWEET, FIT FOR THE REFINER, FROM BEET-ROOT GROWN BY HIMSELF AS AN ORDINARY FIELD CROP.

BY

EDWARD LEFROY CULL,

OF

THE CANADA COMPANY, TORONTO.

TORONTO:
GLOBE PRINTING COMPANY, 26 AND 28 KING STREET EAST.
1872.

PREFACE.

One of the greatest men England ever produced has said: "The man who makes two blades of grass grow where one grew before is a benefactor to his race."

The writer most humbly hopes that the introduction of a new crop and a new industry to his brother colonists, may entitle him to the kind consideration of the class for whom this treatise was prepared. If it does only a little to advance the agricultural and to lessen the outlay of the country on foreign productions, the writer will feel himself amply rewarded for the expenditure of much time and trouble and considerable outlay and expense incurred in a great number of practical experimental trials during the past two years.

EDWARD L. CULL.

TORONTO, CANADA,
10th Jan'y 1872.

THE WHOLE HISTORY AND MYSTERY

OF

BEET-ROOT AND BEET-ROOT SUGAR.

INTRODUCTORY.

"Beet root sugar! Ah yes, we all know they make a great deal of it on the Continent of Europe, more particularly in France and Germany, but as no manufactory of it can be conducted except on an enormous scale, and with a heavy outlay of capital, it will not suit Canada where labor is so high, and the climate is unfitted for it."

This is the observation which the writer has had to combat in speaking of the subject with every tolerably well-informed person, while to those who knew nothing about it, the matter seemed to be enveloped in such a hopeless mystery that few could be got to approach it. After exhausting every other objection the caviller would say: "You do not understand the subject yourself; you have never made beet root sugar; book learning wont answer in a case of this kind;" and so on.

To meet these objections there was but one course, namely, to go at once into the practical manufacture of the article on a small working scale; to learn the whole business, and be able to reply to objections; my knowledge is derived not from books alone, but from practice as well. I make such an article of crude sugar that it is saleable to the refinery, in the following manner; obey my instructions and you may make it too.

As, however, it is important to carry the reader fully with me, I shall show how it was that Beet Root Sugar first came to be used, and why it has been considered a *sine qua non* that it should be made on a large scale.

Beet Root Sugar, as a national production and grand article of domestic use and manufacture, originated with the great Emperor Napoleon. His continental system, and the enormous wars attendant thereupon, cut France off from communication with the Tropical climates where the sugar of the world had at that time been produced, and thus deprived the nation of a grand necessity, as well as a grand luxury (for it is now considered by all that not only is sugar a luxury but a necessity in the broadest sense of the term), and Napoleon well understood that, although, a nation under certain circumstances will submit to be debarred from civil and political rights, yet touch the human family in any matter of daily use or daily indulgence, and they become ungovernable.

Under these circumstances he called the great chemists of France together and said, France requires sugar, the tropics are closed to us, our supply of sugar is cut off. It must be had as an article of French production and home industry; the nation requires it: the resources of the empire are at your command; but sugar must be had at any cost; make it.

The entire chemical talent of France was, therefore, turned to this point. At first they made a chemical sweet which was called sugar, but it was not sugar, and did not meet the public requirements. Then they turned their attention to the beet root, and they found that this root would yield the required substance.

But chemists as a body are governed by entirely different rules from mercantile manufacturers; chemists look chiefly to the

success in their processes without counting cost; to the mercantile manufacturer everything else must bend to cost, his ultimate end is profit.

The French chemists not only had to supply sugar, but to supply it on an enormous scale, and the works were erected of a corresponding magnitude—the works were not calculated for *profit* but for *supply*—and as the manufacturers could in the first place demand their own price (as sugar, in France, could be obtained nowhere else) the works were *made*, in some measure, remunerative as well as to afford the public what was wanted.

After the continental war was closed, and the French were again able to enter the markets of the world, and get sugar as cheaply as any one else, the first real struggle of the beet sugar manufacturers commenced. They had to work against slave labor and against cane sugar, and also against the accumulations of stock and production and preparation for growth which had taken place while the continental markets wese closed; and then for the first time it became a fair race between beet sugar and cane sugar. About that time also the beet sugar people got a great advantage over their opponents of the tropics by the abolition of slavery in the principal sugar producing countries, and it was then (with the exception of Cuba, Brazil, and the United States) free labor in the tropics with the sugar cane against free labor with the beet in Europe; and the beet sugar has ever since gallantly held its own against all opposition.

It was during this struggle that the enormous factories of beet sugar did good service to the cause; they had so much capital locked up in them that further expense to keep their position became a matter of necessity, and no cost was spared to produce efficiency, and it was then that the great improvements in the manufacture were made.

The processes were, however, kept as secret as possible, and the public was carefully indoctrinated with the idea that beet sugar could not be profitably made except in the enormous factories on the continent.

Modern science and enquiry, and the easy communication of nation with nation of the present day have gone far to open up the close corporation of the beet sugar manufacturers, and it will be seen by the following record that the mysteries so long shrouding the process, have been swept away, and the full particulars are now offered to the world at large.

The writer claims nothing absolutely new in the process set forth: the arrangement of the various processes is new; but more so by the suppression of superfluities than by additions. The new part of the process is the fact that by following the instructions hereafter given, twenty-five pounds of beet root may be manufactured into a merchantable sweet, in domestic utensils as readily as two hundred and fifty tons of beet root are ordinarily reduced in one of the monster factories of the European continent.

THE MANUFACTURE OF BEET ROOT SUGAR.

The most important thing the person can do who is to enter upon this manufacture is to forget all and every thing he has ever known about sugar making, particularly that which is made from the Maple; and he must especially bear this maxim in mind, viz:—

Beet Root Sugar is not, never has been, and, the writer believes, never can be, made into an article of domestic use, until it has been refined by a separate process.

It is an article which is made by the producer to sell to the refiner, and not to use as it is made by the first manufacturer. The crude article is quite equal in value, according to the sugar it contains, to the best brown cane sugar, commonly called muscovado, and far superior (when well made) to the lower grades of sugars, (those with a fine soft grain), which come from tropical climates.

All sugars, except maple sugar, are made at two processes—in the first the juice, whether from the sugar cane or from the beet, is defecated and boiled down to the crystallizing point; it is then set by in cisterns until the crystals have formed, when it is shovelled into barrels, and the molasses is made to drip from the sugar. The sugar is then shipped to England and America and elsewhere, and refined into loaf and into the

finer kinds of soft sugar in the great Refineries.

In France and Germany all the great manufacturers produce the sugar first as crude sugar, and then refine it; they are now, however, in many instances working the branches separately.

Cane sugar, even when made at the best season, in the best manner, and from the most favourable growth of cane, contains a large proportion of molasses and uncrystallizable sugar which will not, and does not in its native state, crystallize. The after processes of the refiner, however, finally extract all that portion which will crystallize from that which will not, and the latter is disposed of as treacle, or as the various grades of golden and other syrup.

It is quite true that a considerable portion of the sugar from the sugar cane is used as a domestic sweet in the shape of brown sugar, but even this has been partially refined; but by far the greatest quantity of sugar used is refined in the great English and American Refineries before it reaches the public.

Canadian ideas of the manufacture of sugar are formed from the maple sugar made on the farm. This is the purest source of sugar which the vegetable kingdom supplies. It has deposited all its woody portions and impurities in the tree, the growth of which it nourishes, and we get it filtered and purified to the greatest possible extent.

Beet sugar must not be looked at for a moment with the same ideas or treated in the same manner.

The beet root contains besides sugar and woody matter, portions of albumen, pectine, and other substances, and also a flavouring matter of a strong beety odour, but chiefly large quantities of potash and salt.

Were it not for the potash and salt, and the strong beety flavour before spoken of, the juice of the beet when defecated would boil down into a pure crystallizable sugar, at once usable as maple sugar is.

It is the beety flavour and the potash and salt which we have difficulty in getting rid of. —These matters, however, yield at once to the operations of the refiner. The only portions of the extract from the beet root which in the refiner's hands are not made use of is the essential oil which causes the strong flavour, and any other impurities which ought to have been removed before it comes to his hands. The mixture of potash and salt when extracted from the syrup and purified is really worth weight for weight, at least as much as the sugar.

Where people wish to engage in the manufacture of alchohol from the beet root, they can do so to a great profit, as beet root yields to the distiller far more spirit per acre than the best crop of either grain or corn does. The apparatus for distillation is quite simple and comparatively inexpensive.

The following table will show the money value obtained from the entire beet root crop in France *alone*, in the year 1865-6, and it must be remembered that Germany, Belgium, Holland, Austria, and Russia, all make their own sugar, or at all events the greater portion of it, from the beet root, and in all cases it must also be remembered that the beet root industry is one that has been, and is, constantly increasing.

The beet harvest of 1865-6 in France alone produced

275,000	Tons of raw sugar worth	£6,250,000.
100,000	Pipes of strong spirit—each pipe containing from 100 to 120 gallons, part distilled from the root direct, without the assistance of the sugar manufacturer, and partly from the molasses, and worth - - - -	1,350,000.
20,000	Tons of potash, worth	500,000.
1,600,000	Tons of pulp, worth	1,000,000.
		£9,100,000.

This is what is produced from the entire beet crop—not the value of the produce of the sugar manufactory.

The imports of beet root sugar at the British and Scotch ports for the first eleven months of 1871 were 134,480 tons, against 56,670 tons for the same period in 1870, and 31,060 for the same period in 1869; this shows the enormous increase of the manufacture.

Now, it is perfectly ridiculous to suppose (in the face of such a statement as the foregoing) that Canadians and the inhabitants of

America generally, are going to confess inferiority to the French and Germans, and to allow it to be said, we have not nationally sufficient intelligence to make sugar from beets, when the continental nations are able to assist in supplying the world with that necessity.

Some people have been rash enough to say that our climate and soil are not fitted to produce the root rich enough in sugar to pay. This we most emphatically deny. The extended trials of the American patent office, and the numerous instances of Canadian grown beets which have during the last two years come under the writer's hands, all show beyond question that Canadian beets, where well selected and well grown, are as rich in sugar as the best French and German or continental beets. If any one doubts it, all he has to do is to grow a patch of the best kinds of sugar beet in his field or garden, and following the instructions hereafter given reduce the roots to such a state that the amount of refined sugar they contain is easily proved by the ordinary tables and instruments. Others will say, and they are far the most practical, If it can be done, why has it not been done? In reply, I affirm that it is only because the manufacture has been made a mystery of and has not been understood. The chief trouble of the manufacture has consisted in the unerystalizable sugar, and this, it is now proved beyond a doubt, has been caused not by the sugar contained in the well grown root being inferior, but by the process adopted being imperfect. If the following instructions are carefully carried out, all difficulties and troubles as to unerystalizable sugar will cease to be a serious obstacle.

With these few observations, I propose to lay before the readers of this little treatise, full instructions for the growth of the sugar beet and its conversion into such a class of crude sugar as is best fitted for the refiner, and in every way equal for the purposes of refining to the best tropical sugar that is produced.

SUMMARY OF THE PROCESS.

I shall first describe in very few words what is necessary to do, and then more at length the best way to do it.

The roots are washed with great care after being stripped of the leaves, and the crown being cut off, taking care not to break off the small lower end of the roots, which are richest in sugar.

The roots are then rasped down into the finest possible pulp.

The pulp is then pressed so as to get out the juice in the most perfect manner, and clear from all particles of root.

The juice is then put in the boiler and brought to a boiling heat.

As soon as the juice boils, you add to it milk of lime, carefully made from fresh burned lime-stone. The way to make milk of lime will be described further on.

The addition of the milk of lime checks the boiling and you will see the juice turn from its black disagreeable color to a light shade, at the same time it breaks into flocks, a kind of curdling taking place. You stir the juice just enough to mix the milk of lime all through it, but not enough to break up the flocks or curdlings.

As soon as you see that the juice clears between the flocks (which will be in the course of a minute or two), the whole contents of the boiler are, as rapidly as possible, cast on to a filter cloth of canvas; as fast as it strains through the canvas it must be pumped back on it until the juice runs through the canvas bright and clear as wine. It should be of the color of pale sherry.

When you find it run clear let it go into a shallow vessel, and cool as quickly as possible.

When the liquor has cooled down to 120° Farenheit, set the carbonatation bellows (hereafter described) to work, and continue to pump or blow the carbonic acid fumes from charcoal, or hard anthracite coal through the liquor. This gas destroys the causticity of the lime, and makes it into a carbonate, and it then falls down in the liquor like a fine mud.

You continue to blow the gas from the carbonatation bellows through the liquor until all caustic in the lime is destroyed. This is known by the thick mud settling rapidly out of the liquor, leaving it clear and fine.

Then take some of the clearest in a glass, or, if you can do so, filter a little through a close cloth, until it is fine, then blow with a pipe or straw your breath from the lungs

through the liquor. If your breath muddies the liquor, the bellows have not worked long enough. If your breath does not muddy the liquor, the carbonatation is complete.

Then filter the whole through canvas unti it is quite bright and as fine as wine, returning the first runnings until it runs clear. It will be quite bright, and may be a little darker than it was before it was carbonated.

It is now fit to evaporate down into syrup; and as soon as it reaches the proper density, or proof, it is set by in a warm place, and in the course of eight or ten days the whole mass will crystallize into coarse dark crude sugary substance, and this then, as soon as it is parted from what little molasses it contains, is fit for the refiner.

Had the syrup been evaporated in a vacuum pan (as it ought to be when the operator can afford it), the crystals of sugar instead of being brown will be nearly white, and only require the cleansing action of jets of steam in the turbines, will be described further on.

As soon as the crude sugar is all crystallized, throw the mass into the turbine, which is then made to revolve rapidly, and the molasses are thrown off through the wire gauge, or perforated sides, of which the turbine is composed.

The resulting sugar, although not fit for domestic use, is then fit for the refiner, and is at once a saleable article.

The molasses are set by to crystallize again, after having been exposed to the osmose process, which is described further on. Where the crystallization is very complete, it may be a question whether it is not better worth while to feed the molasses to the pigs and cattle than to purify it; but it must be fed in very small quantities. By doing so the farmer gets the full benefit of all the salt and potash in his manure, which it is a most important thing to do. In small quantities it is very wholesome and fattening to the cattle.

The only drawback to growing beets on a farm for sugar making, and that is more a theoretical loss than a practical one, is the loss of the potash and salts which go off in the molasses; but they are retained by being fed to the cattle and hogs; and if this course is pursued, the beet farm would in a very short time attain such a pitch of fertility as to render exhaustive crops now and then an absolute necessity.

With these plain instructions before them those who cannot make a crude merchantable article of beet root sugar are certainly not fit to conduct any business or farming operations on anything but the most limited and consequently unprofitable scale.

Where, instead of making sugar from the beets, spirit is distilled and the slop or refuse and the pressed cake from the roots are used on the farm, beets may be grown in the same land year after year with an annually increasing productiveness. This has lately been proved in England (and long since was proved in France and Germany). In England beets which are used for distilling have been grown on the same land for seven years following with the best effect, the manure from the former crop being used, and the crop in the later years more than doubled; while from the continuance of hoed crops the weeds have been all but exterminated. What a prospect this holds out for our Canadian thistle infected lands.

The same effects would follow in making sugar from the beet provided the molasses were fed to the stock.

In all the departments in France and in Germany where beet sugar is grown and manufactured, the yield of wheat produced in those departments has been more than doubled, and that notwithstanding that potash and soda is made from the refuse of the sugar and sold and taken away from the the land, thus really depriving the land of important mineral constituents—so fertilizing to the farms is found the feeding of the beet root pulp and the increase of manure from the numbers of cattle kept on it, in spite of the loss of potash and salts in the sugar crop.

We will now go more closely into particulars and begin with the—

CULTIVATION OF THE ROOTS.

The proper cultivation of the roots is one of the great requisites to ensure success in the manufacture of beet sugar. The culture and planting, should be such as to ensure roots of small size, not exceeding 3 to 4 lbs. each, and often under this standard. The crop will be equally or more productive in

sugar, if the major part of the roots are grown so thick, in the row, as to ensure their asmll size. The after management, must also cause the root to be almost or altogether under the earth; as, if otherwise grown, that part exposed to the light, will not yield a full supply of sugar; and it has been the received opinion of many analysts that glucose instead of crystallizeable sugar is thus formed. The seed should be sown in drills about 18 inches from centre to centre, and the roots may stand at 6 inches apart in the row. Of course they will be thicker at first, but may be thinned to that distance. The land should, and must be pulverized and prepared so that when burying the seed there may be about one and half inches of fine mould to fill in over it. At all events the depth of the seed must not exeeed two inches, when covered n; and above all things a moist time should not be neglected to complete the sowing. The seed to be sown may be either the Vilmorin or white Silesian; both are good, but ordinary unnamed sugar beet must be avoided, as it too often is only white mangold wurtzel. The preparation of the soil is most important; in fact, it is imperative that to ensure ease of culture and certainty of crop, one course should be pursued. As to soil, any quality of good dryland will answer well, and any previous crop will not materially affect the following beet yield. But it is absolutely requisite that the following course be followed. We will suppose the land that is to be sown with beets, has been summer fallowed—If this course is pursued it will amply repay the time lost, and expense incurred by doing so: but fallowing although advisable, is not absolutely necessary. About the beginning or end of September haul out the manure—any kind will do, but some is very desirable—spread a thin coating over the field, then ridge and furrow the land, throwing one furrow each way; exactly the same as if you were hilling up potatoes. The manure will then all be directly under the ridges, so formed. Nothing more need now be none to the land before the middle of April, by that time the seeds commence to sprout, and tiny small, plants can be seen. You must now construct a harrow, or succession of very small light double harrows, so small that each will take a ridge, there must be a joint in the centre to allow each wing to travel on one side of each row. All the weeds will be killed by this harrow and the rows will not be lowered more than one half the original height. Once each week the land must be harrowed until the middle of May—when all the weed seeds within the influence of the air will have germinated, and the land be absolutely clean. Now sow the seed, and two weeks or less will see all the plants up in rows, and no weeds to injure the growth. There you see you have expended very little labour on the land, only once ploughing, and this is all to be done in the fall; your land is clean, fine, and free from weeds; the beets will then get the start of any that may subsequently grow. Directly you can do so with safety to the young plants, run the horse scuffler between each row. This implement must be so constructed as not to do too much. The weeds will be small and easily destroyed. A slight hoeing in the row may be necessary, but if the land was fallowed the year previously, there will hardly be any occasion for it. But if the land be not fallowed, the same system must be pursued. The same fall manuring, the same ridging up, and the same harrowing in the spring. Whereas if an opposite course is followed, and the work all done in the spring, the weeds will have a fair even race with the beets. The land will have laid dead and wet all winter without any early spring drying and exposure to the air by the furrowing system. And in many cases there will be a fortnight's difference in the time at which the seeds can be sown. It will readily be seen, that all the manure will be *under* the ridge, and nearly double quantity of surface soil will be *in* the ridge, and there will be so much more depth of earth for the plant to penetrate, instead of being forced out of it, there being no doubt that every pound of root grown at the bottom, deeply buried in the earth is worth one and a half pounds of that portion exposed to the air and light. Hence the necessity for earthing up; and this must be done occasionally with a double mould-board plough, so set or constructed that a little fine earth can be raised from between the rows and deposited nicely on each side of the plant, leaving however, a small ridge out of which the green may grow.

The rains will wash these small ridges down somewhat. When in England some years since, the writer used such a plough for a number of seasons with excellent effect.

About the last of September the roots will be ripened sufficiently to commence grinding and pressing, and we now come to the most troublesome part of the process so far as cultivation of the root is concerned. Hitherto every thing has depended, (so far as trouble of manipulation is concerned), on suppressing the growth of weeds until the beet plant shall have sufficient power to overgrow them, and if the foregoing directions are carefully followed there will be but little trouble or expense. The preparation, manuring the land in the fall cannot be too strongly enforced. By so doing you have the manure all well decayed just when the plant requires it; you have a double depth of earth for its growth over the ordinary level field; you have the land dry and wholesome for spring harrowing; you have above all things the start of the weeds, and ever afterwards during that year the beets will be ahead in the race instead of being at times overrun and half smothered, and during the summer you have a depression into which all weeds will naturally be swept by the action of hoeing, which thereby escape all chance of rerooting after rain, in the row, and you have an easy mode of cultivating during the summer with a properly constructed scuffler, between the rows as occasion requires.

WASHING THE ROOTS.

The roots before being submitted to the rasp, must be thoroughly washed in a rolling cage, great pains must be taken that no dirt shall be allowed to remain on the roots when they come to the rasp, and the heads of the roots and leaf stems must be carefully cut off; and if cattle are kept to consume the portions of the root which come from the press, so that waste would not occur, the whole head of the root ought to be cut off, and fed to the cattle. It has been proved time and again that the extremity of the root end of the plant is the richest in sugar, whilst the portion which is grown above the ground is the part which contains the largest proportion of potash and salt. hence in the continental countries of Europe where the government excise duty is charged on the roots consumed; the entire portion of the root which grows above the ground is cut off and rejected for sugar purposes. Any plan which will insure perfect cleanliness in the roots, is that best adapted to the work, and the roots should be allowed to drain off all superfluous water, before they come to the rasp.

THE RASPING THE ROOTS.

The roots should be presented to the rasp endwise, and the rasp (however constructed) should reduce the root to the finest possible pulp. The pulp should then be passed through rollers working together, which are of sufficient surface to receive and crush, the pulp as it comes from the rasp. The rollers will thus reduce the pulp to a perfectly smooth paste, and burst all the cells of which the root is formed, and which cells contain the sugar.

There are many ways of making the rasp. That is the best which works with the greatest speed, and reduces the root to the smoothest and most complete pulp.

PRESSING THE PULP.

The following is the old fashioned plan. There have been, and will be many improvements. The pulp must be placed by small parcels at a time, (according to the size and power of the press), on strong canvas cloths, each cloth being laid over a frame about 2 inches deep, and the size that will go into the press; the cloths must be much larger than the frames. When the frame is full, fold over the cloth first from side to side, then the ends over; then place the cushion of pulp so formed in the press; there must be a strong board larger than the cushion of pulp, and it must rest on one board while another covers it; one board going one way of the grain, the next above crossing it, and so on, parcels of pulp and boards until you have the press full. Then put on the power gradually, so that the juice can escape readily from the cloths, without bursting them; press to the full power of the screw, and take care to catch all the juice.

The juice should run from the press at once into the kettles, where the heat should be raised as quickly as possible to 150° Farenheit's thermometer, and it should not fall below this heat, so long as the kettle is filling.

When all the juice is out that you can get out at the first operation, with the press; take the cakes of pulp, put them in hot water, and let them soak for an hour. The water must be nearly boiling, as the cakes will cool it sufficiently. When broken up and mixed with the hot water which they should be at once, the heat ought to be between 150° and 155° (Far.); and if not so, add more hot water until that heat is attained; then cover up, and keep it all hot. This is necessary to prevent fermentation or acetification. Then proceed to press the mashed roots again, in the same manner as at first.

It is scarcely worth while to squeeze the pulp more than twice, although it ordinarily takes three pressings to get out all the sugar. If your press is sufficiently powerful you can get out all the juice at once.

Strain the juice through a fine strainer, and get the juice into the kettles as soon as possible. Neither the first juice nor the second must ever be allowed to fall in heat, below 150°, or souring may commence. when in the kettles heat the juice as quickly as possible, to just boiling; then add the lime in the following manner; the juice will be very black, and dirty looking, but it will all come right with the lime.

TO MAKE THE MILK OF LIME.

Get some good, new, hot lime, slack it in boiling water; stir it up and let it settle for a minute or two, and pour the liquor off the dregs; you must leave all the coarse part of the lime behind, only take off the *milk* of lime, which must be quite smooth and without grit.

This should be made and put in a barrel; the lime must be caustic and strong; when kept under water it will keep for any reasonable time in a caustic state. When the juice boils, add some of the milk of lime to it, and stir it slowly. When you find the juice change colour, and curdle, shewing clear in spots, and when it shows signs of settling, you have put lime enough; stir the juice gently until the lime is mixed well through it, but don't urge the juice to a rapid boil; then take out a sample in a glass and see if it clears, and is the colour of white wine if so enough lime has been put; if not, put a *little* more, but don't put more lime than enough. As soon as the juice flakes, or curdles, it is done. It need not be more than five minutes, from the time you put the lime, until you filter the juice.

Now empty the juice as quickly as possible, out into a canvas strainer, formed by stretching a canvas cloth so that it hangs down in the middle; it should spread as wide as possible, so as to give the greatest amount of filtering surface. As long as the juice runs thick, you must pump back again on the filter taking care that it shall enter the juice in the filter, with as little disturbance as possible. When the juice runs clear, let it drain through the filter cloth without further disturbance. It should be as clear and bright as any wine; it is then right.

Let the strained juice get cold, and it will then be ready for carbonatation.

Although the juice is now so fine and clear, yet there is a great deal of lime in it, though you cannot see it, and this lime is caustic. This causticity must be destroyed and the lime turned into its original chalk or lime stone, though in a state of fine mud; and this is called carbonatation.

CARBONATATION.

To effect this operation, you must get a pair of blacksmith's bellows, or any other good blowing machine, and have a pipe fixed to the nozzle which is to go down into the juice; the pipe should be long enough to curl round the bottom of the vessel which contains the juice, and it must be pierced full of small holes, so that when the bellows are worked, the air they contain will be forced in numerous small streams, through the liquor. But the air alone will not carbonate the lime; so you must make the following arrangement. Get a number of lengths of common stove pipe, to a length of from ten to fifteen feet, at one end is fixed a charcoal stove, with the means of closing the top, so as to enable you to draw the air as much as possible through the charcoal fire, fill the stove and light it; as soon as the coal burns clear from smoke, it will be ready to use. The object of the length of the stove pipe, is to disperse and let the heat pass off, so that you may not burn the bellows. The end of the pipe away from the stove must be fixed by a flexible tube to the hole in the bellows, which is intended to draw in the air, then by working the bellows the air will be drawn

through the charcoal fire, and be turned into carbonic acid gas; this gas is then forced into the juice, which it carbonates. You can use either charcoal, or anthracite coal, as the latter affords carbonic acid gas as well as the former, and is better in some respects where it can be had, for the dust and ashes of the anthracite does not contain potash, or other salts that would be mischievous to the syrup, and any dust that gets in can readily be strained out.

The syrup should be cold if you have any means of keeping down the froth, which will be raised by means of the bubbling of the gas through it from the bellows; but if you have no such means, just warm enough to keep a *little* grease, such as butter, melted on the surface of the juice; the syrup or juice won't froth with the grease; but the grease does not improve the sugar.

You must keep the bellows driving the gas from the burning charcoal, or anthracite, until you see that the chalk or lime is all set free, and settles well, then take some of the fine clear liquor which has been carbonated, and put it in a glass, and blow through it with a reed or straw, from your breath for five minutes. If it gets thick, you have not carbonated it enough. As soon as you are satisfied that it has been thoroughly carbonated, strain it through a filter cloth, in the same manner as at first; but the cloth must first be well washed and perfectly clean, and the syrup or juice will then be fit to boil down into sugar. If you don't do it right the first time you must try it again, but the lime must be all out of it before you evaporate it down for sugar.

You may then boil the juice down to a proper consistency, and if all has been well done it will crystallize into brown crude sugar in about eight days; but the syrup during this time must be kept about as warm as fresh cow milk. During the process of evaporation, the syrup should be strained through a filter bag several times.

When ready to set by to crystallize, the syrup must be so thick that when a drop is parted between the finger and thumb, it ought to break across the thread, and the ends turn a little; it must be perfectly bright and clear though the colour may be dark. It had better however, be a little too thin than too thick, as the thin syrup will get thicker whilst set by to crystallize, and it is believed that in that shape, it makes larger crystals.

Now, the difficulty with beet sugar has always been the crystallization, and the trouble has been what the Germans and French call "slime sugar;" but if the foregoing rules are *exactly* followed, there will be no slime sugar, or treacle—sacrcely enough to enable you to get off that portion of the syrup which contains the salts, and which must be got out from the mass with the turbine. If you proceed to the second, operation bear these few rules constantly in mind. In the first operation when you add the milk of lime to the juice to clear it :—

1st. Never keep the lime in contact with the *hot juice a minute longer than you can help it*; the lime cannot be dispensed with to clear the juice, but its action on the hot juice produces more or less of slime sugar.

2nd. Do not agitate the juice with the lime in it, more than enough to mix. or you will spoil your filtration; the larger the flakes remain in the juice the better it will filter.

3rd. Never carbonate at any other than a low cow milk heat. If you carbonate hot, as most of the books tell you, you will make slime sugar.

Of course throughout all the process of boiling, heating, and evaporation, you must be extremely careful neither to burn, nor even brown the syrup. The syrup will always be highly coloured; but if it has not been burned, all the colour comes out without waste in the after processes, and if the process of evaporation is conducted in the best manner, the sugar which crystallizes out of the coloured syrup, will be nearly if not quite white. The burned sugar can never be recovered.

The above is as far as the writer would recommend any farmer, or any but a sugar refiner to carry the process. If the foregoing instructions are well carried out, the thick syrup produced is just in the proper state for the refiner,—and it will always command a reasonably good and remunerative price.

The foregoing instructions are the result of *actual experiment*, and may be relied on as the result and experience of two years' continual experiments on a working scale.

REFINING.

The foregoing is as far as in the writer's opinion any farmer or small manufacturer ought to go in the preparation of an article for the manufacture of beet root sugar. There is nothing in the foregoing processes which a person of ordinary intelligence and information cannot do. The process is a simple one, and the result, an article of a certain commercial value.

Refiners of sugar want to get their crude materials with as little done to them by people who do not understand refining as possible; as they have certain processes to go through, and they do not of course want to have to amend the blunders of other persons; and any attempt at partial refining, or the use of chemicals by the producer, is quite as likely to be wrong as right, for the after processes; but as every one wants to know something more about the method of refining the crude material before described, and as many persons are adapted to follow out such after processes with success, I shall now proceed to describe in general terms the process of sugar refining, with this caution, that I only go into the matter generally, and that no one should go into much of an outlay in the refinery process, until he has by experiment made himself thoroughly master of the subject. It is one that admits of experiment; and success, (so far as the result of refining) can be attained on the small as well as on the large scale; that is, any man after studying the subject can refine one pound, or ten pounds of the before described crude material, into pure sugar; but he will not be able to make use of the refuse, nor to do things in the economical manner in which they are done in the large refineries, he must not expect to be able to conduct the business on a profitable scale. Nevertheless it may suit a number of persons who may prefer to manufacture at home, at no profit, rather than purchase, even if they do so at what to the manufacturer would be a positive loss. I shall proceed to give such instructions as will enable those wishing to do so, to carry out the process of preparing beet root sugar, and converting the crude article into such a sweet as will be consumable in a family.

The decolorizing of the syrup and the destruction of the strong beety flavor, before spoken of, are accomplished entirely by the use of animal charcoal, which consists of burnt bonse, prepared in a particular manner, and brought to such a state that the syrup will only percolate through the vessel which contains the bone charcoal at a slow rate. The bone charcoal is put in tall narrow vessels made of copper or boiler plate, often in some of the larger refineries as much as from 20 to 30 feet high, and of a breadth of from three to four feet. In other refineries the dimensions are different. In the beet sugar factories in France and Germany, the size of the bone black filters is generally 12 to 15 feet high, and a diameter of about 40 inches. There are several of these in a factory, and they are each so arranged that juice, syrup, hot water, cold water, and steam can be severally applied as wanted. There are tight covers held in their places with screws, to fill and to empty the filters, and also means of applying chemical subatances and gases to the bone black as it becomes saturated with impurities, and requires to be cleansed.

After these filters have been worked but comparatively a short time, they lose their power of destroying the color and peculiar flavors of the syrup or juice. The filters have then to be emptied, and the bone black heated to a dull red in closed iron vessels, so as to burn out the impurities which have destroyed its peculiar powers. The bone black is then quenched and cooled out of contact with the air in properly prepared machines, and the filters are again refilled—to be again emptied, and the coal reburned as soon as it becomes exhausted.

The burning of bone charcoal and also the revivification of the bone black when it has been used, are very offensive operations; so much so, that they are not allowed to be carried on in the City of London, which *was* the great centre of sugar refining; and the cost of burning and reburning,—carting, into, and out of, the City of London, has been so great, as to seriously injure the trade, which has been principally removed to Glasgow, where the civic authorities are less sensitive to smells, and more sensitive to commercial prosperity.

It is this bone charcoal business, that will

always prevent the refining to any great extent of beet root sugar by the farmer and small manufacturer: the amount of capital invested in the bone black, and the necessary machinery, and utensils are enormous, and the business must be continuous, and extended all the year round.

Another reason why the refining of sugar cannot be profitably carried on by any one but a person largely in the business, and whose works are carried on continuously, is the expensive and complete nature of the evaporating vessels which are necessary, and which are called vacuum pans. These are machines in which, owing to all the air being extracted, and the syrup boiled by the heat of steam "in vacuo," the watery particles are evaporated from the sugary substance at so low a heat, that not only is the operation carried on with great rapidity, but at so low a temperature that burning or browning the liquid is impossible; and consequently the sugar is produced from the vacuum pans in a colorless state, and on crystallizing becomes white sugar. All white sugar is thus made.

But these pans are very expensive machines, and require great steam power, and skill to work them; and although doubtless substitutes of a much more simple form, and at less cost, will eventually be produced, yet at present this class of machinery is entirely beyond any person who is not a capitalist, and may therefore be banished from the minds of the farmer and small manufacturer; but that will not prevent the farmer and small manufacturer from producing the crude sugar before described, and which when well and carefully made, will be in the very best possible state for the use of the great refiner.

With these observations I will now proceed to describe, how the amateur can decorolize the beet juice and syrup so that it shall crystallize into a form of light brown sugar. It cannot be white without vacuum pans. First, as soon as you have the beet juice boiled down to a tolerably thick syrup, you must (in order to obtain the best results), submit the syrup to the "osmose" process, which is done by exposing the syrup in a thin stratum on sheets of parchment or parchment paper (the latter is very cheap) while on the other side of the paper water is applied, so that the water touches every part of the parchment paper. The salts which are contained in the syrup, owing to their being possessed of a greater power of what the chemists call "diffusability," pass through the parchment paper into the water, while some of the water passes back into the syrup and thins it somewhat: a little sugar passes with the salts, but in very small quantities; the main body of the syrup remains behind on the parchment paper in a greatly purified state, and is in great measure deprived of the potash and salt which it contained. When the process has been continued for as long a time as you may consider necessary, (I have kept it in this position from half an hour to a whole day) you remove the syrup and proceed to evaporate it further, until it gets thick enough to crystallize into sugar: let it remain until the crystals are well formed; then pour it out on a fine sieve or put it into a turbine and let the molasses drip from it; then the molasses (which contain nearly all the remaining of the salts,) may again be submitted to the osmose process, and the syrup be again crystalized.

The resulting sugar, when you have enough of it together, should then be redissolved, and reboiled, adding to the liquor before it boils some bullock's, or pig's blood, or white of eggs and a small quantity of finely powdered bone black; the blood or eggs and bone black will cause nearly all the remaining impurities in the sugar to rise in a scum to the surface: as soon as the liquor boils, this must then be removed, and the syrup be well strained, and again evaporated and crystalized, and the result will be brown sugar of tolerable purity.

In order to show how much potash and salt you take out by the osmose process, evaporate the water after it has been exposed to the osmose operation, and finally burn the residue at a red heat in an iron pan, this burns up all the sugar and other organized substances which have mixed with the salts; then dissolve the ashes of the salts, by washing the iron pan which has been heated red hot, and filter the resulting liquor through blotting or filtering paper; the liquor will come through the filtering paper quite bright and clear, and colorless but so strongly alkaline that you cannot mistake the potash and salt, or doubt the large quantity which has been removed from the syrup.

What has thus far been written will show any thinking person that the thing to be done for the benefit of the farmer and small manufacturer of Canada, is to manufacture the crude article ready for the use of the refiner and not to interfere in any way with that most expensive and difficult branch of the business.

Full practical information, accompanied by proofs and experiments on a working scale (made in the presence of parties who require it), and also analyses of beet root, so far as the quantity of sugar it contains, will be furnished on application by letter post paid to John A. Cull, Esqr., P. O., Toronto.

SUPPLEMENT.

COST AND EXPENSES OF LABOUR, AND GENERAL ESTIMATES OF ONE OF THE GREAT BEET SUGAR FACTORIES OF EUROPE.—This is copied from Crocky's work on Beet Sugar, which is the best and most reliable work yet published in English. The reader will see that the allowances for Wages and Salaries are most liberal.

The Factories work day and night, and the wages are reckoned at four shillings sterling *per shift* of 12 hours, which for the old country is very high. The amount of Beet roots worked up in this Factory is twenty thousand tons in a season. The following is Mr Crocky's language and figures:—"With perhaps the exception of two or three men, no skilled labourers are required in New Beet sugar works, as most of the operations are of a simple Mechanical nature, easily taught to inexperienced country hands, by a competent superintendant and his overseers.

The only skilled hands really needed are, an Engineer, an hydraulic pump man, a defecater, a sugar boiler, and a bone black burner. Of these the defecater and sugar boiler should have already had some experience in a Beet Root Sugar Factory."

* * * * * *

We have added as a separate item, the necessary additions to be made for the extra salaries to be paid to specialists in the various departments.

The calculation is based on a campaign of 100 working days.

WASHING AND PULPING,	
Transportation and washing of the Beets, 14 men 2 shifts per 24 hours, *sterling* 2800 days labour at 4s.	£560 0 0
PRESS DEPARTMENT,	
28 men 2 shifts per 24 hours = 5600 days at 4s.	£1120 0 0
Sack washing and darning, 8 women 2 shifts, 1600 days at 4s.	320 0 0
DEFECATION.	
8 men per 24 hours—equal to 800 days labour at 4s.	160 0 0
SCUMS.	
6 Men for 24 hours, 600 days at 4s.	£140 0 0
CARBONATATION.	
250 days at 4s.	50 0 0
Monte jus, (that is steam pump men)	40 0 0
Preparation of Carbonic Acid, (i. e. from the Charcoal),	40 0 0
FILTRATION.	
3 Men every 24 hours, at 4s.	60 0 0
CONCENTRATION.	
2 Men every 24 hours, at 4s.	80 0 0
BOILING.	
2 Men every 24 hours.	80 0 0
CRYSTALLIZATION AND CENTRIFUGALS.	
1500 days' labour.	300 0 0
GENERATION OF STEAM.	
2 shifts of 3 men, 600 days, at 4s.	120 0 0
BREAKING AND PACKING.	
5 men at 4s.	100 0 0
MEN IN THE YARDS, ETC.	
5 Men at 4s.	100 0 0
MANAGEMENT.	
1 General Superintendent and two overseers	800 0 0
Book-keeper and Clerk	320 0 0
EXTRAS.	
Carpenter, Plumber, Smith, 3 men.	300 0 0
Extra pay to skilled labourers	500 0 0
General total cost of labour for one year's Campaign	£5190 0 0

The quantity of coal consumed in such an establishment as we have described, would average 600 tons, which, at 15s. per ton, would cost..... 450 0 0

The bone black, 30,000 lbs., would cost for the first outlay 2½d. per lb., £312 0s. 0d., but in succeeding years would only amount to replacing the waste.

The lime used would amount to 4,500 bushels, and cost £280 0s. 0d.

The cost of 15,000,000 lbs. of Beet root to be worked up into Sugar would at 12s. per ton be.....£4,500 0 0

ANNUAL EXPENSES.

Summing up the above we calculate that the yearly expenses will amount to:

Labour.....£5,190	0 0
Coal..... 450	0 0
Boneblack Waste..... 100	0 0
Lime 280	0 0
Purchase of beet roots. 4,500	0 0
Add 20 per cent. for incidentals.....2,100	0 0
We have a total of.....£12,620	0 0
To which has to be added Taxes and Insurance, which we have computed at..... 400	0 0
Interest on capital invested..... 960	0 0
Making a Grand Total of.....£13,980	0 0

The total cost of erecting the works for the above factory, is given at.....£13,157 0 0

This factory is fitted for the manufacture of Sugar from Beet roots, for the produce grown on 500 acres of ground, which ought to produce at least 1,200,000. One million two-hundred thousand pounds of raw Sugar.

REALIZATION.

The products to be realized in our example of a Sugar Manufactory would be as follows:

Sugar from 15,000,000 lbs. of Beets at 8 per cent of Sugar,—the Sugar being sold at 24s. per cwt. (of 112 lbs.).....£14,400	0 0
2,700,000 lbs. pulp calulated at ½d. per lb..... 5,620	0 0
5,000 gallons of molasses at 40° Baame at 1s. per gallon..... 250	0 0
Residue as fertilizers..... 200	0 0
£20,470	0 0
Deducting annual expenses and interest as above.....13,980	0 0
Leaves a net annual profit of.....£6,490	0 0

There is every reason to believe that with careful management the quantity of sugar will range as high as 10 per cent, instead of 8 per cent, which we have taken as our basis.

In such a case the net income would be £24,470.00; and the net annual profit £10,090.00.

Other authors make their calculations on an entirely different basis,—and arrive at results equally favourable, though differing somewhat in detail.

That the above is not too sanguine a view to take of the probable yield is shown by the fact that during the season of 1868, 1869 in the Zollverein, 2,500,000 tons of beet roots produced 207,500 tons of sugar, a return of 8.40 per cent.

The foregoing quotations speak no doubt of land in the highest state of fertility, and which has been manured for years in the most scientific manner, and also, there is no doubt, of land which has been specially selected for the purpose, and which by repeated crops of Beet root very well manured with the refuse and the results of the cattle fattened; has been brought into the most favourable state possible for the crop.

One of the most remarkable features of the growth of the sugar beet industry is, the constantly increasing crop and yield per acre which the proper culture of that crop produces not only in the amount of roots grown per acre and their richness in sugar, but also in the constant increase of other crops particularly wheat throughout the district.

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